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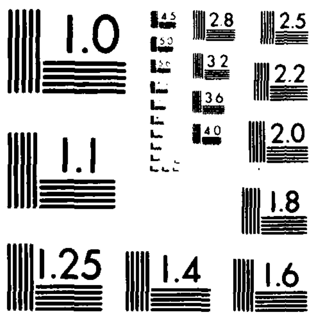

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Report No. FAA-CT-80-37

DETECTION OF MILITARY AIRCRAFT IN AN AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS) ENVIRONMENT

Carl Hazelwood

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA •

FINAL REPORT

DECEMBER 1980

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16. Abstract

An initial survey and analysis of military Air Traffic Control Radar Beacon System (ATCRBS) transponder problems was conducted as a result of transponder performance analyzer (TPA) measurement difficulties encountered at Dobbins Air Force Base, Georgia, and from field problem reports from the Atlanta Terminal, New York and Washington Centers, and other areas. The information assembled and presented in this report demonstrates potential ATCRBS problems with high performance military aircraft in fringe areas of coverage and particularly with the Automated Radar Terminal Systems (ARTS's). Aircraft antenna patterns and switching are of primary concern.

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METRIC CONVERSION FACTORS

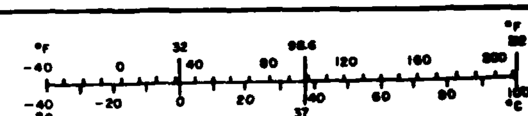
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

Efforts to collect Air Traffic Control Radar Beacon System (ATCRBS) transponder performance data from military aircraft at Dobbins Air Force Base (AFB), Georgia, were made by Federal Aviation Administration (FAA) Technical Center personnel at the request of the FAA/Southern Region. Difficulties were encountered during the collection process which emphasized the need for further investigation. The purpose of this report is to present information obtained to date for use in field problem investigations and consideration.

BACKGROUND.

The Atlanta Terminal had reported difficulties in tracking low flying military aircraft, particularly high performance aircraft such as the F-105, operating out of Dobbins AFB. This same type aircraft has also been reported as having transponder difficulties by the New York and Washington Centers and by other traffic control facilities. The problems reported are: poor tracking, loss of target, and/or excessive coasting.

DISCUSSION

The transponder performance analyzer (TPA) data collection at Dobbins AFB resulted in failure for several reasons (none of which necessarily imply malfunctioning or inoperative transponders). First, reply pulse amplitude variations of 2:1 were observed. Second, certain interrogation sequences automatically generated by the TPA resulted in erroneous interrogations for the transponders, e.g., modes I and II. The replies were then erroneously interpreted by the TPA resulting in false data. Third, lack of knowledge concerning the military transponders and, in particular, specific aircraft installations resulted in data inconsistencies and misinterpretation.

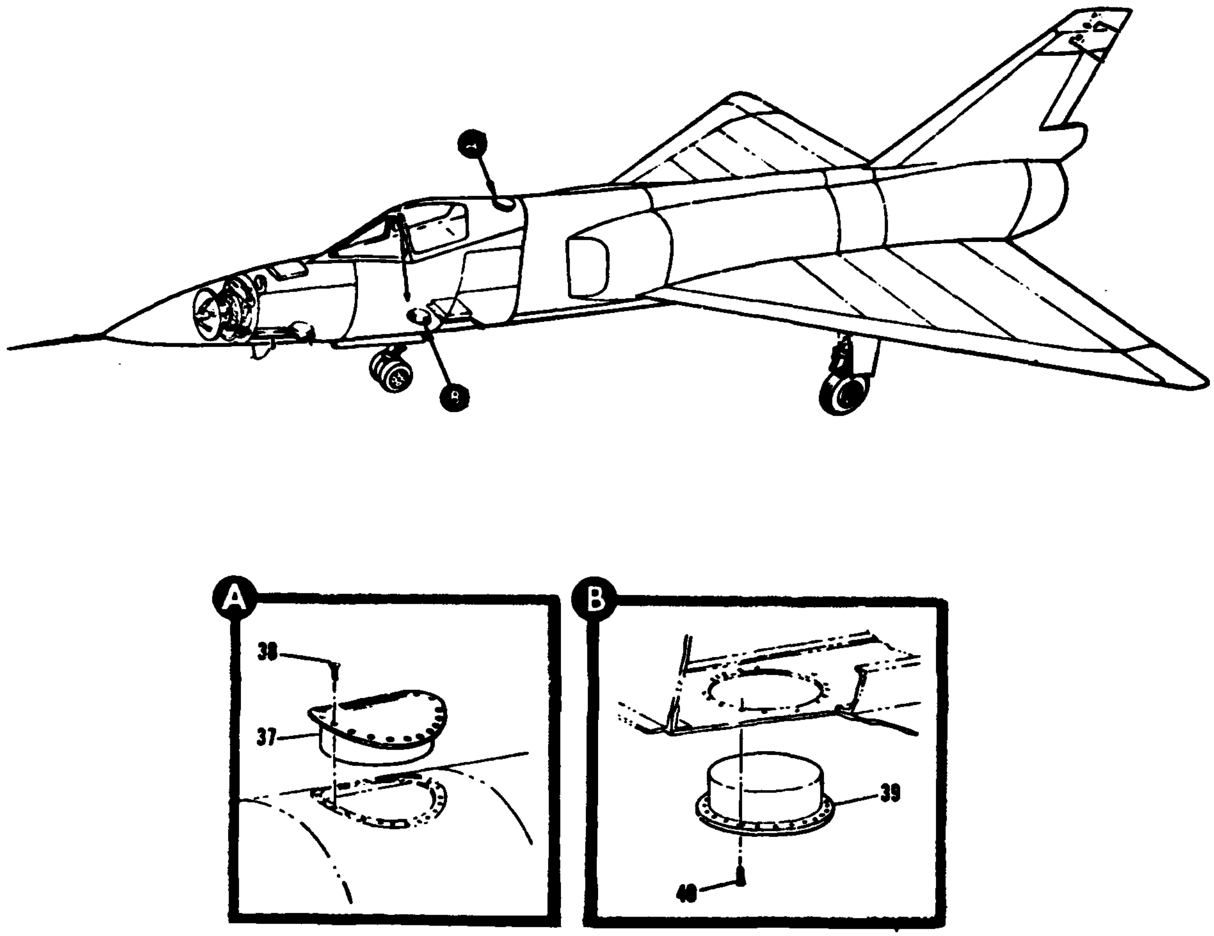
It was discovered during investigation of the various problems that a number of high performance fighter-type aircraft utilize dual antenna systems. The F-105, for example, has one antenna on top, forward of the cockpit, and a second antenna on the bottom, aft, behind the hook (see figure 1). The antennas are switched alternately at a 38 hertz (Hz) rate. (A switch inside the cockpit selects either the top only, bottom only, or both which automatically switches from one to the other at the 38 Hz nonsynchronous rate.) Table 1 lists other aircraft with known switch capabilities, rates, etc.

A high percentage of these aircraft also utilize skin or flush mounted antennas as shown in figure 2 for the F-106 aircraft. The skin-mount or "pie plate" antennas are not considered as efficient as stub antennas; however, aerodynamic considerations require the flush mounted design with sacrifice of antenna performance.

A third factor in the antenna system is the long cable runs required in aircraft such as the F-105. The F-105 has approximately 40 feet of cable run to the tail antenna and results in additional signal attenuation which could become critical in fringe areas of coverage. Maintenance personnel have also indicated radiofrequency (RF) losses through the antenna switch as high as 10 decibel (dB), which indicates a problem in the switch. This would seriously affect both power and sensitivity of the transponder.

One of the most important factors of consideration is the antenna pattern of the aircraft. This is particularly true where installations result in nonsymmetrical patterns. This is also one of the most difficult measurements to conduct and is usually done by modeling.

FIGURE 1. F-105 ANTENNA LOCATIONS



F-106

80-37-2

FIGURE 2. F-106 ANTENNA INSTALLATION AND TYPE

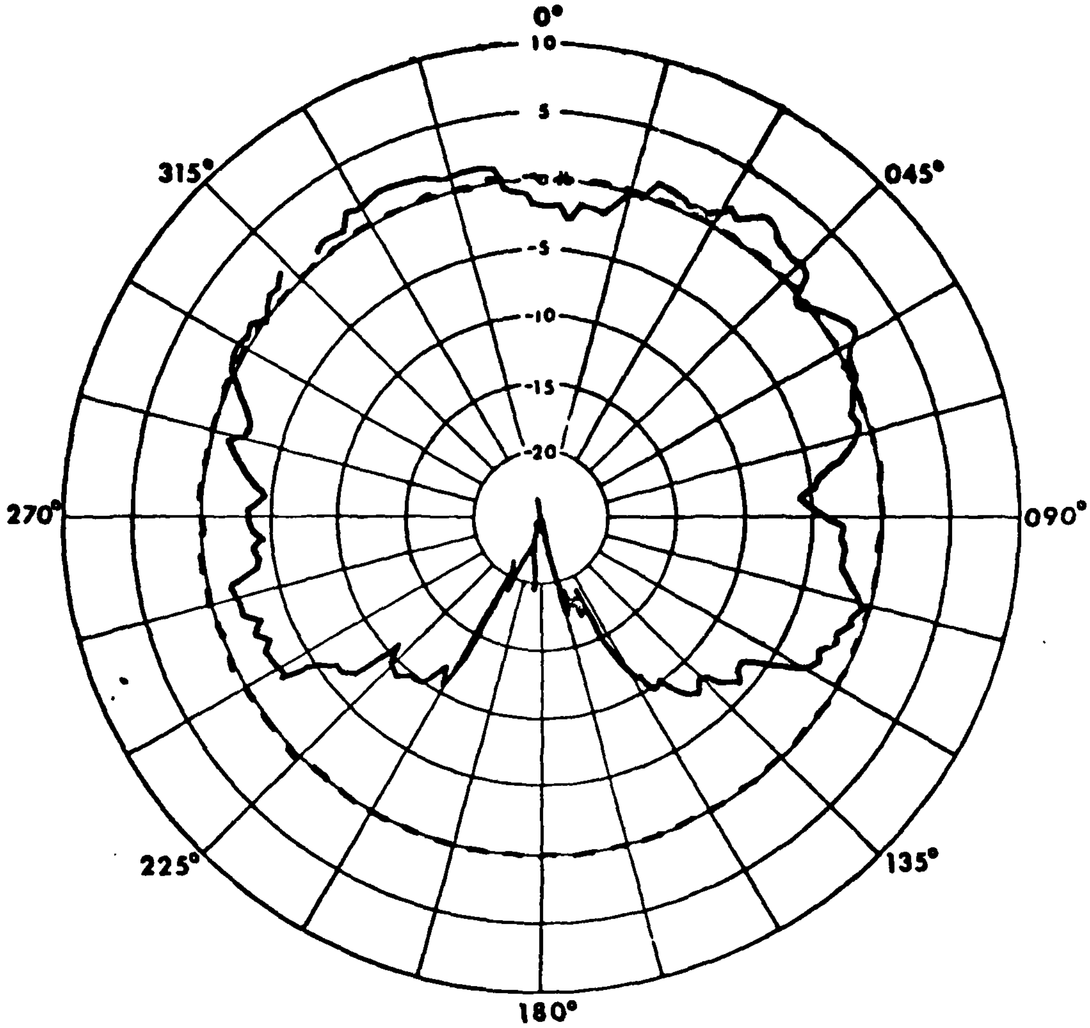
TABLE 1. ANTENNA SWITCH CONTROLS

F-105:	SWITCH SELECT FOR TOP, BOTTOM, BOTH (ALTERNATES - 38 Hz)
F-106:	NO CONTROL - AUTOMATIC SWITCH (ALTERNATES - 38 Hz)
F-4:	DUAL ANTENNA - SWITCH CAPABILITY UNKNOWN (ALTERNATES - RATE UNKNOWN) (TOP - FORWARD OF CANOPY; BOTTOM - 2 FEET FROM TAIL, NEXT TO HOOK)
F-4	TOP ANTENNA ONLY - BEHIND CANOPY
F-16	DUAL ANTENNA - DUAL DIVERSITY, REPLIES ON ANTENNA WITH STRONGEST RECEIVED SIGNAL LEVEL

Patterns for the various aircraft are generally not available; however, patterns for an A-4 aircraft were obtained from the Naval Air Station, Patuxent River, Maryland. These patterns are given in figures 3 through 7 for -15 degrees and -5 degrees below the aircraft plane of flight. The top antenna for this aircraft is forward of the cockpit and the bottom is near the tail, behind the hook. The F-105 configuration and patterns would be similar. As noted from figures 3 and 4, the pattern from the top forward antenna is reasonably symmetrical toward the nose and sides of the aircraft; however, a deep null exists from the tail of the aircraft. The aft (bottom) antenna for -15 degrees (figure 5) is reasonably symmetrical in all directions; the -5 degree pattern (figure 6) shows nulling from the front (nose) of the aircraft. Smaller angles encountered in normal operation would be worse. Figure 7 shows the combined forward (top) and aft (bottom) pattern to be reasonably symmetrical in all directions which would probably function with a fair degree of success in the older broad band, raw video type controller displays and equipment.

The newer sophisticated equipment, such as the Automated Radar Terminal System (ARTS) and the National Airspace System (NAS), are much more demanding and stringent on quality of input data and would experience difficulties since both antennas do not operate simultaneously. For example, site parameters in some ARTS facilities require 11 hits for target declaration. If the aircraft should happen to be in a fringe area, outbound from the site, and the site pulse-repetition frequency (PRF) is 380 or below, the maximum number of hits would be 10 before the aircraft switches to the forward antenna and would probably be lost. If detection began in the middle of a cycle, then a hole for at least 10 hits would exist in the middle of the site antenna scan. The effect of this on ARTS would be excessive coasting and target drop-out.

A different problem exists with the F-4 and aircraft with similar type installations. This particular aircraft has a single pie-plate antenna mounted immediately behind the cockpit canopy. Antenna pattern data on this aircraft are unavailable; however, there is reasonable assurance that it would not be detected at high altitudes since the antenna would be shielded. The Navy A-7 aircraft has the antenna in the top tail section. This aircraft would probably have poor detection from the front and/or during landing/takeoff with a nose-up attitude toward the site antenna.



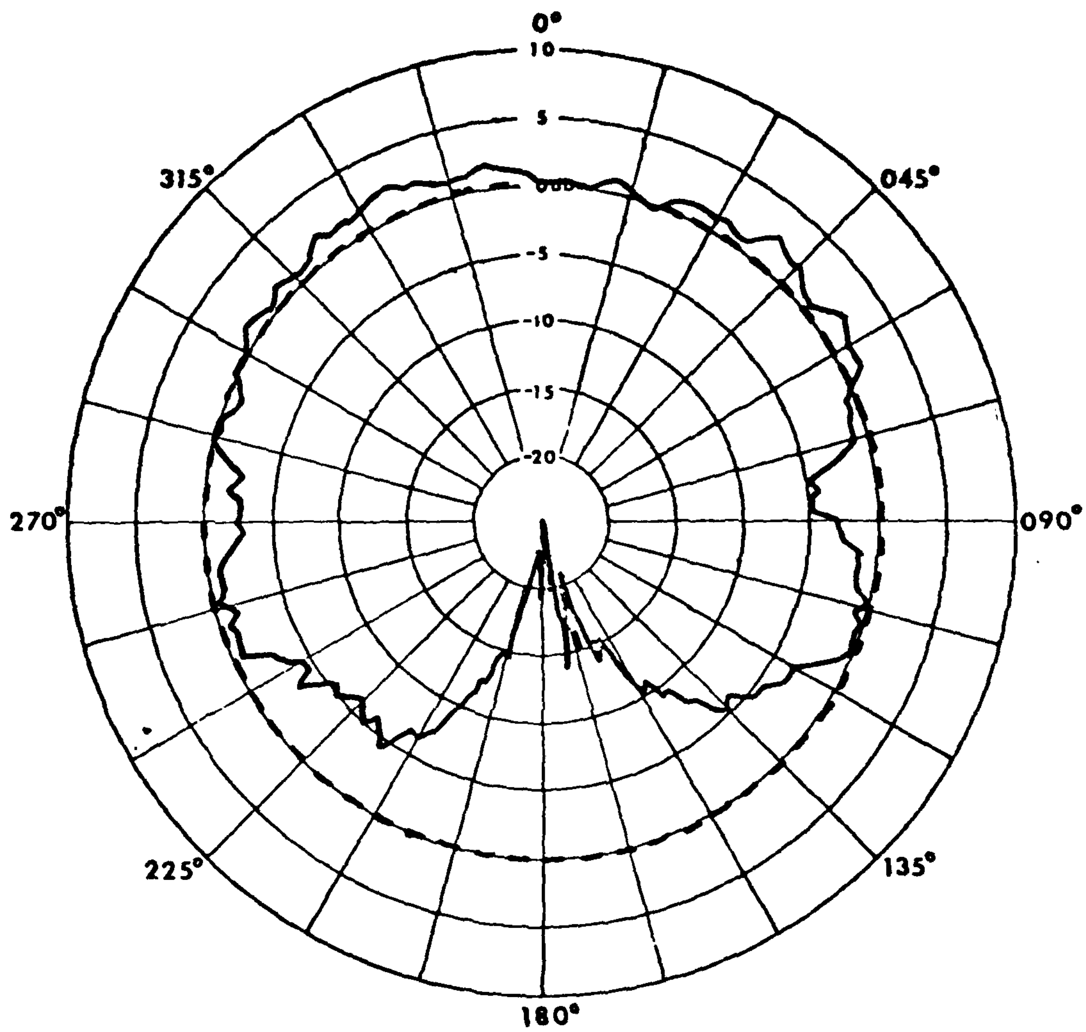
Top Forward IFF Antenna Pattern
A–4F BuNo 154175

Aircraft Configuration: no external fuel tanks
Test Frequency: 1070.0 MHz

Scale: dbl versus azimuth angle
Elevation Angle (ψ): -15.0 degrees

80-37-3

FIGURE 3. A-4 ANTENNA PATTERN, -15 DEGREES, TOP FORWARD ANTENNA



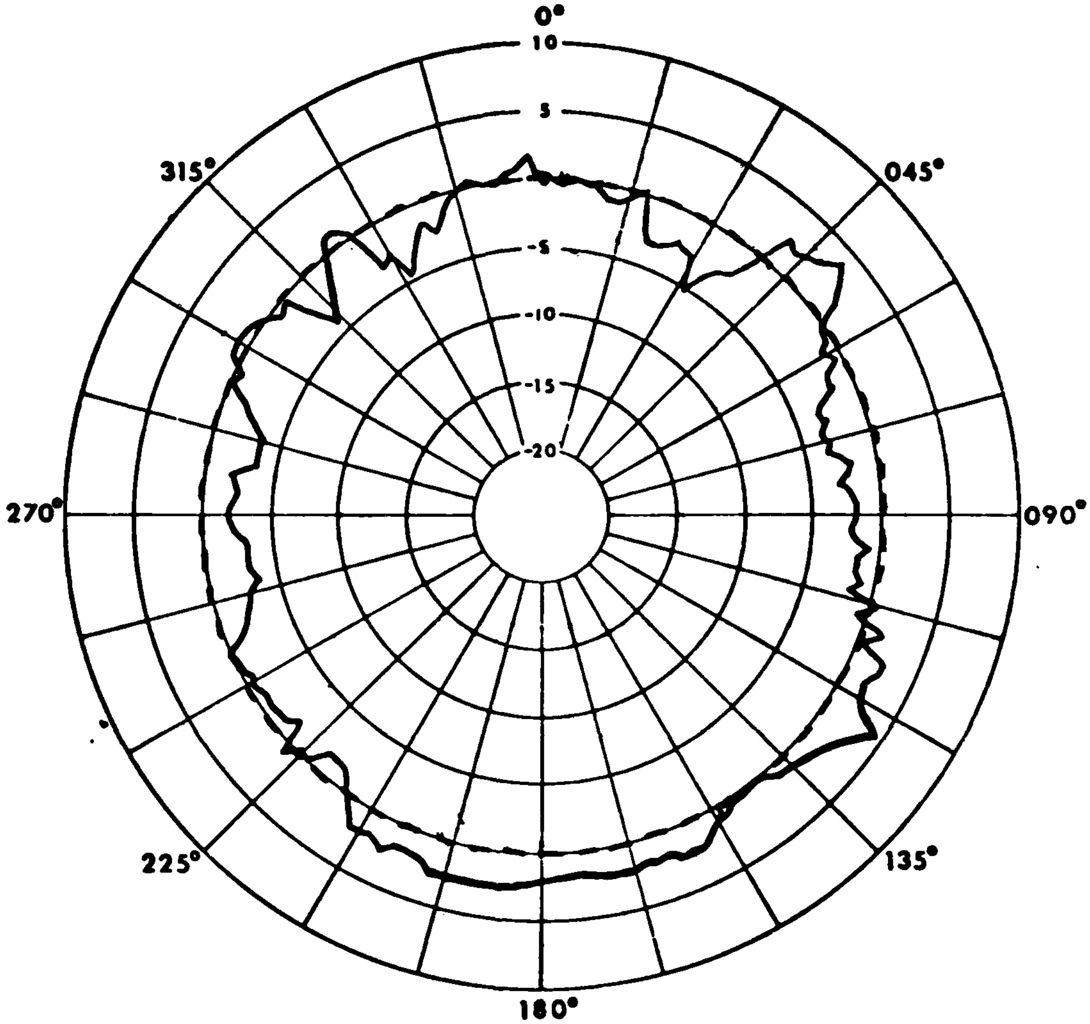
Top Forward IFF Antenna Pattern
A-4F BuNo 154175

Aircraft Configuration: no external fuel tanks
Test Frequency: 1070.0 MHz

Scale: dbl versus azimuth angle
Elevation Angle (ψ): -5.0 degrees

80-37-4

FIGURE 4. A-4 ANTENNA PATTERN, -5 DEGREES, TOP FORWARD ANTENNA



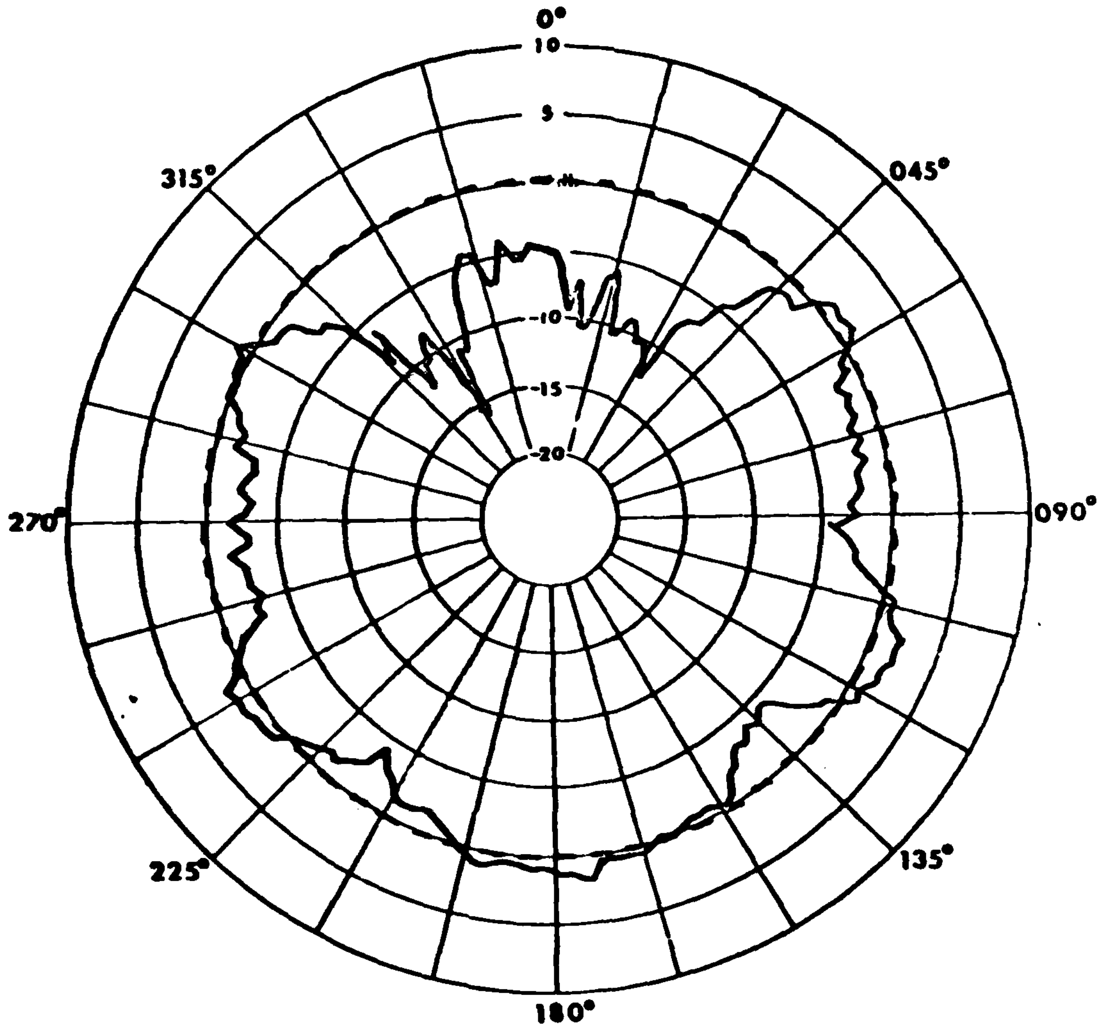
Bottom Aft IFF Antenna Pattern
A-4F BuNo 154175

Aircraft Configuration: no external fuel tanks
Test Frequency: 1065.0 MHz

Scale: dbl versus azimuth angle
Elevation Angle (ψ): -15.0 degrees

80-37-5

FIGURE 5. A-4 ANTENNA PATTERN, BOTTOM AFT, -15 DEGREES

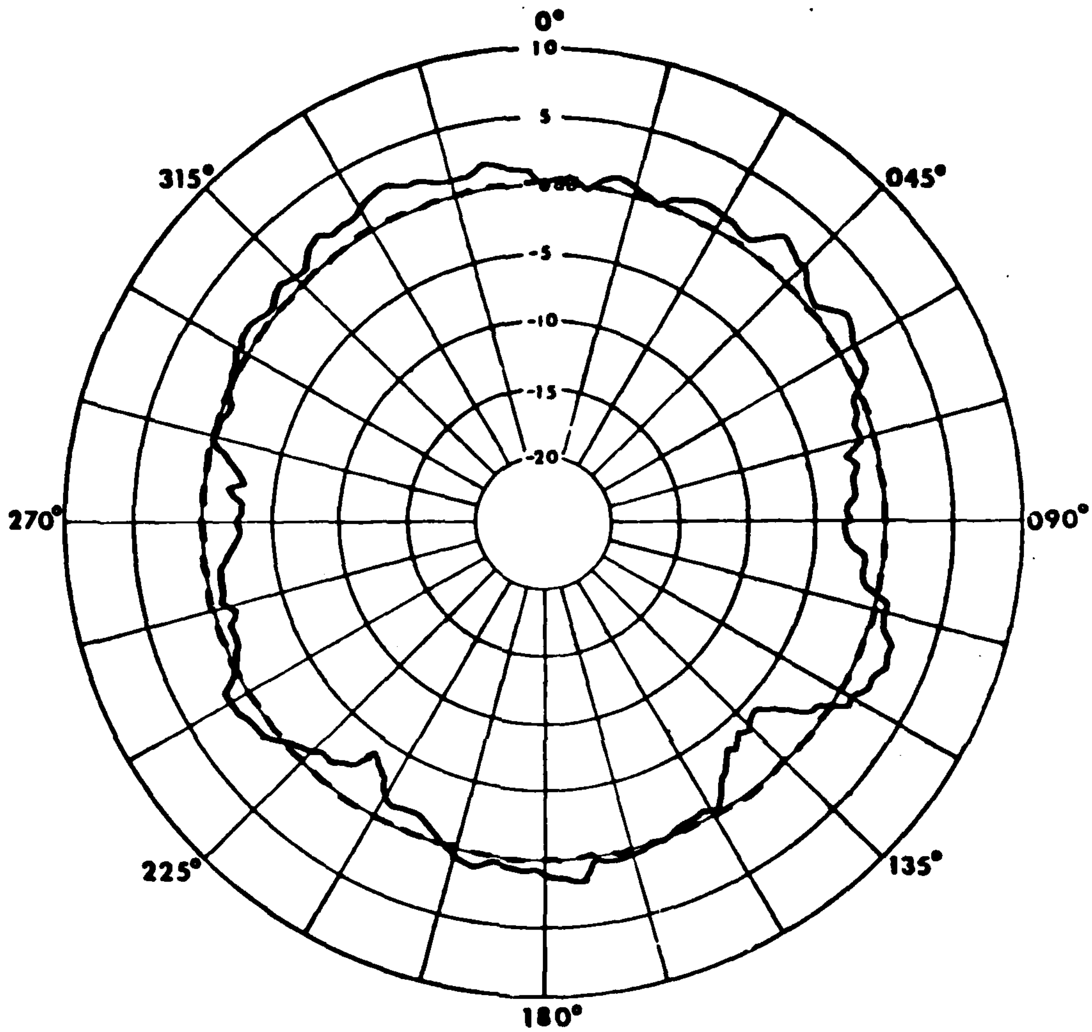


Bottom Aft IFF Antenna Pattern
A-4F BuNo 154175

Aircraft Configuration: no external fuel tanks
Test Frequency: 1065.0 MHz

Scale: dbi versus azimuth angle
Elevation Angle (ψ): -5.0 degrees
80-37-6

FIGURE 6. A-4 ANTENNA PATTERN, BOTTOM AFT, -5 DEGREES



Combined Top Forward and Bottom Aft IFF Antenna Patern
A-4F BuNo 154175

Aircraft Configuration: no external fuel tanks
Test Frequency: FWD 1070.0 MHz
AFT 1065.0 MHz

Scale: dbl versus azimuth angle
Elevation Angle (ψ): -5.0 degrees

80-37-7

FIGURE 7. A-4 COMBINED TOP AND BOTTOM ANTENNA PATTERNS, -5 DEGREES

It also has been reported, but not confirmed, that certain type aircraft utilize the antenna on a time share basis. The same antenna is reportedly used for tactical air navigational aid (TACAN), ATCRBS, and digital communications on a time share basis. In addition, certain aircraft installations are reported to use cross suppression from distance measuring equipment (DME) interrogation to ATCRBS transponder to prevent front end overdrive of the transponder. This time share and cross suppression would reduce still further the possible hit count from that aircraft.

At some installations, preventive maintenance is also a problem area with the military transponders. The transponders are only removed and repaired if found defective on ground checks, i.e., periodic maintenance and calibration are not performed.

The F-16 aircraft uses a dual diversity antenna system with dual antennas; the transponder replies on the same antenna that receives the strongest interrogation signal. This system should provide reasonably satisfactory operation provided there are no excessive losses (3 dB or less) in the cabling and connections.

FLIGHT CHECKS.

After consideration of the above information, it was decided to conduct flight tests with both F-105 and F-106 aircraft. With the cooperation of the New Jersey Air National Guard, an F-105 was scheduled from the 108th Tactical Fighter Wing McGuire AFB, and an F-106 from the 177th Tactical Fighter Wing, FAA Technical Center, Atlantic City Airport, N.J. Both aircraft flew direct from Atlantic City (ACY) omnidirectional radio range (VOR) to Waterloo, Maryland (see figure 8), and returned. This is a distance of approximately 50 miles one way. Both aircraft were visual flight rules (VFR) at an altitude of 4,500 feet and flew at different times to minimize garbled beacon replies.

The Terminal Facility for Automation and Surveillance Testing (TFAST) with an ARTS III input/output processor (IOP) was used for data collection purposes. The TFAST uses a 4-foot open array antenna with a gain of 23 dB and operating at 12.74 revolutions per minute (rpm). The antenna was developed by Hazeltine Incorporated, and is the developmental predecessor to the 5-foot array presently in process of deployment to field facilities. The site utilizes an Air Traffic Control Beacon Interragator (ATCBI)-5 System and site parameters were adjusted for 160 watt (W) transmitter output with approximately 90 W into the antenna, PRF of 343, 1:1 interlace, Side Lobe Suppression (SLS) ON, and Sensitivity Time Control (STC) curve adjusted for 39 dB.

The ARTS hit count parameter for target declaration (HY4) is adjusted for 4. No coverage problems have been found with the system. The normal ARTS EXTRACTOR program was used for data collection to record target replies, target reports, range, azimuth, altitudes, beacon code, etc.

The F-105 made three round trips at the 4,500 foot altitude to approximate the situation at Atlanta. The first run was using the top antenna only, the second run the bottom antenna only, and the third run both antennas. The pilot was instructed to fly both modes 3A and C; however, mode C was not turned on until the third run with both antennas.

The F-106 aircraft only flew one round trip since the pilot does not have control of the antenna switching. This aircraft flew the same flight scenario as the F-105, i.e., 4,500 feet VFR, modes 3A and C.

FLIGHT DATA ANALYSIS.

Computer printouts are provided for each run of the test aircraft. Tables 2 thru 7 give the data for the F-105 runs; tables 8 and 9 present the data for the

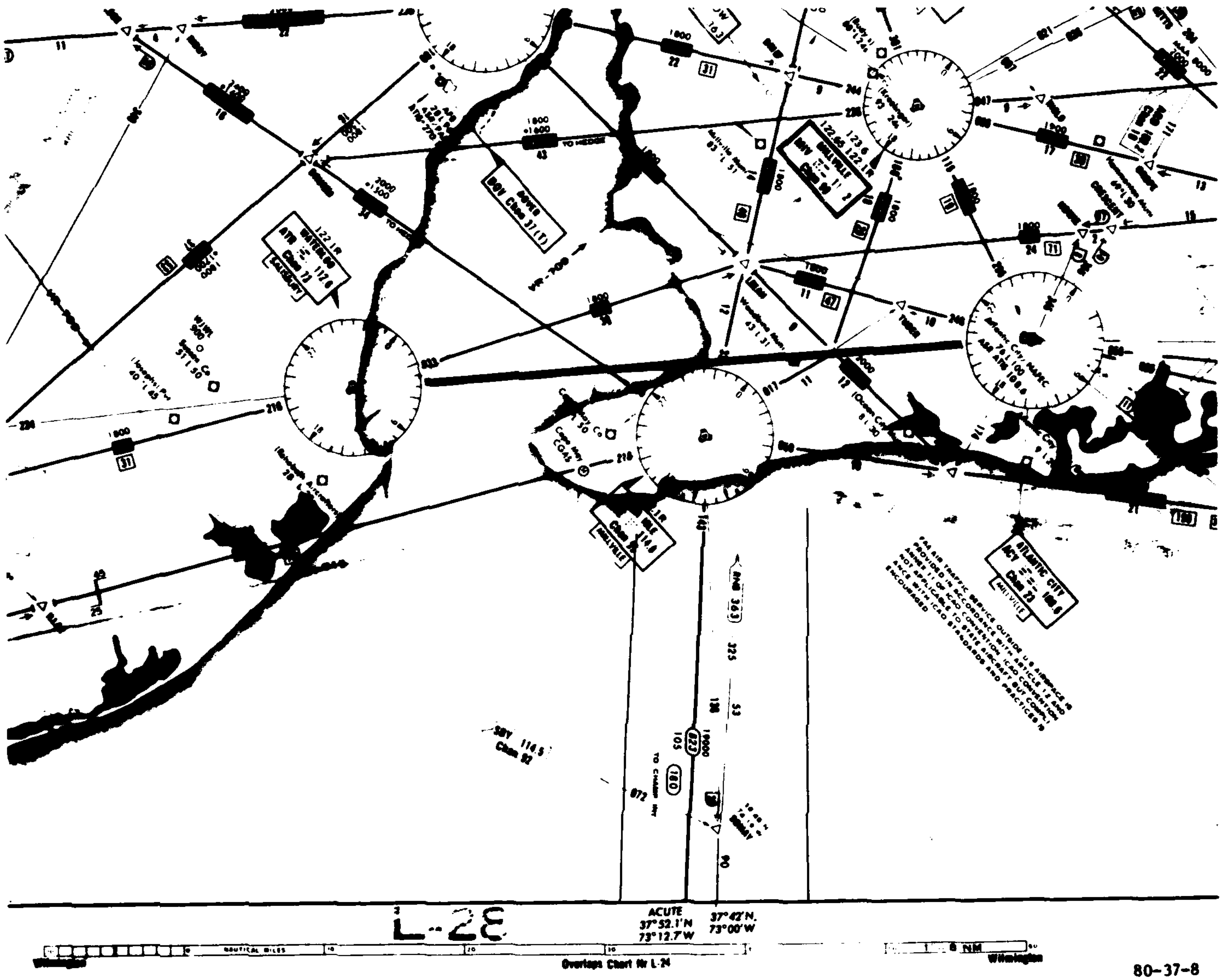


FIGURE 8. F-105/F-106 FLIGHT TEST ROUTE

TABLE 2. F-105 FLIGHT TEST DATA, INBOUND TO BEGIN RUN 1

RECORD # 2 SCAN # 1 FILE # 1

	AZ	RG	CODE	ALT	VA	VC	RL	HC
B	447	333	1233	0	3	0	21	11
B	446	323	1233	0	3	0	21	11
B	442	314	1233	0	3	0	23	12
B	440	304	1233	0	3	0	21	11
B	435	275	1233	0	3	0	23	12
B	432	265	1233	0	3	0	23	12
B	426	256	1233	0	3	0	23	12
B	425	246	1233	0	3	0	21	11
B	420	237	1233	0	3	0	21	11
B	415	230	1233	0	3	0	23	12
B	412	220	1233	0	3	0	23	12
B	406	211	1233	0	3	0	23	12
B	403	202	1233	0	3	0	21	11
B	374	173	1233	0	3	0	21	11
B	367	164	1233	0	3	0	23	12
B	360	154	1233	0	3	0	23	12
B	353	145	1233	0	3	0	23	11
B	346	136	1233	0	3	0	23	11
B	333	127	1233	0	3	0	23	11
B	316	120	1233	0	3	0	21	11
B	277	110	1233	0	3	0	21	11
B	256	101	1233	0	3	0	21	11
B	231	72	1233	0	3	0	23	12
B	200	63	1233	0	3	0	21	11
B	133	53	1233	0	3	0	21	11
B	55	45	1233	0	3	0	21	11
B	3537	44	1233	0	3	0	23	11
B	3407	51	1233	0	3	0	23	12
B	3271	57	1233	0	3	0	23	12
B	3152	64	1233	0	3	0	23	12
B	3034	67	1233	0	3	0	21	11
B	2720	72	1233	0	3	0	21	11
B	2601	74	1233	0	3	0	21	11
B	2465	75	1233	0	3	0	21	11
B	2354	75	1233	0	3	0	21	10
B	2241	74	1233	0	3	0	21	11
B	2126	72	1233	0	3	0	21	11
B	2012	70	1233	0	3	0	21	11
B	1700	64	1233	0	3	0	23	12
B	1563	60	1233	0	3	0	23	12
B	1447	54	1233	0	3	0	23	12
B	1333	47	1233	0	3	0	21	11
B	1206	41	1233	0	3	0	23	12

START INBOUND TO BEGIN 1st RUN FROM ACY

F-105 TOP ANTENNA

TABLE 3. F-105 FLIGHT TEST DATA, RUN 1, OUTBOUND, TOP ANTENNA

RECORD # 140 SCAN # 71 FILE # 1

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5207	54	1233	0	3	0	7	4	START 1st RUN OUTBOUND FROM ACY
B	5171	64	1233	0	3	0	9	5	
B	5131	115	1233	0	3	0	7	4	
B	5125	125	1233	0	3	0	9	5	
B	5120	135	1233	0	3	0	9	5	
B	5112	146	1233	0	3	0	9	5	
B	5107	156	1233	0	3	0	11	6	
B	5107	167	1233	0	3	0	11	6	
B	5102	200	1233	0	3	0	11	6	
B	5102	210	1233	0	3	0	11	6	
B	5075	221	1233	0	3	0	15	8	
B	5072	232	1233	0	3	0	13	7	
B	5067	243	1233	0	3	0	15	8	
B	5070	254	1233	0	3	0	15	8	
B	5065	264	1233	0	3	0	15	8	
B	5064	275	1233	0	3	0	13	7	
B	5063	306	1233	0	3	0	15	8	
B	5062	317	1233	0	3	0	15	8	
B	5061	330	1233	0	3	0	15	8	
B	5056	341	1233	0	3	0	15	8	
B	5061	352	1233	0	3	0	15	8	F-105
B	5057	363	1233	0	3	0	17	9	TOP ANTENNA
B	5053	374	1233	0	3	0	17	9	
B	5055	405	1233	0	3	0	15	8	
B	5054	416	1233	0	3	0	15	8	
B	5050	440	1233	0	3	0	15	8	
B	5050	473	1233	0	3	0	13	7	
B	5044	504	1233	0	3	0	11	6	
B	5045	514	1233	0	3	0	13	7	
B	5050	525	1233	0	3	0	13	7	
B	5047	536	1233	0	3	0	13	7	
B	5046	547	1233	0	3	0	13	7	
B	5047	560	1233	0	3	0	11	6	
B	5045	571	1233	0	3	0	11	6	
B	5045	602	1233	0	3	0	13	6	
B	5046	612	1233	0	3	0	11	6	
B	5050	623	1233	0	3	0	11	6	
B	5046	634	1233	0	3	0	13	7	
B	5044	645	1233	0	3	0	15	8	
B	5046	666	1233	0	3	0	11	6	
B	5056	710	1233	0	3	0	18	18	
B	5042	1061	1233	0	3	0	9	5	
B	5041	1072	1233	0	3	0	7	4	
B	5043	1102	1233	0	3	0	7	4	WATERLOO TURN

TABLE 4. F-105 FLIGHT TEST DATA, RUN 1, INBOUND, TOP ANTENNA

RECORD # 336 SCAN # 173 FILE # 1

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5035	1245	1233	0	3	0	15	8	← START INBOUND FROM WATERLOO
B	5041	1234	1233	0	3	0	17	9	
B	5043	1223	1233	0	3	0	13	7	
B	5043	1212	1233	0	3	0	11	6	
B	5041	1201	1233	0	3	0	17	9	
B	5041	1167	1233	0	3	0	19	10	
B	5042	1156	1233	0	3	0	17	9	
B	5041	1145	1233	0	3	0	17	9	
B	5044	1134	1233	0	3	0	17	9	
B	5041	1124	1233	0	3	0	19	10	
B	5041	1113	1233	0	3	0	17	9	
B	5040	1102	1233	0	3	0	17	9	
B	5036	1071	1233	0	3	0	19	10	
B	5041	1060	1233	0	3	0	17	9	
B	5035	1047	1233	0	3	0	17	9	
B	5036	1037	1233	0	3	0	19	10	
B	5035	1026	1233	0	3	0	19	10	
B	5037	1015	1233	0	3	0	19	10	
B	5036	1004	1233	0	3	0	19	10	
B	5034	773	1233	0	3	0	19	10	
B	5035	762	1233	0	3	0	17	9	
B	5036	751	1233	0	3	0	19	10	
B	5035	740	1233	0	3	0	19	10	
B	5034	726	1233	0	3	0	21	11	
B	5035	715	1233	0	3	0	19	10	
B	5035	704	1233	0	3	0	19	9	
B	5032	673	1233	0	3	0	21	11	
B	5035	662	1233	0	3	0	21	10	
B	5031	650	1233	0	3	0	21	11	
B	5030	637	1233	0	3	0	19	10	
B	5033	626	1233	0	3	0	21	11	
B	5031	615	1233	0	3	0	21	11	
B	5031	604	1233	0	3	0	19	10	
B	5031	573	1233	0	3	0	21	11	
B	5031	562	1233	0	3	0	23	12	
B	5032	551	1233	0	3	0	21	11	
B	5031	540	1233	0	3	0	23	12	
B	5031	530	1233	0	3	0	23	12	
B	5026	516	1233	0	3	0	19	10	
B	5026	506	1233	0	3	0	23	12	
B	5030	475	1233	0	3	0	23	12	
B	5031	464	1233	0	3	0	23	12	
B	5027	453	1233	0	3	0	23	12	
B	5031	442	1233	0	3	0	21	11	
B	5027	432	1233	0	3	0	23	12	
B	5030	421	1233	0	3	0	23	12	
B	5030	410	1233	0	3	0	23	12	
B	5030	400	1233	0	3	0	23	12	
B	5031	367	1233	0	3	0	23	12	
B	5031	356	1233	0	3	0	23	12	
B	5033	345	1233	0	3	0	23	12	

RECORD # 436 SCAN # 223 FILE # 1

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5030	335	1233	0	3	0	23	12	
B	5030	324	1233	0	3	0	21	11	
B	5027	313	1233	0	3	0	23	12	
B	5030	303	1233	0	3	0	23	12	
B	5032	272	1233	0	3	0	23	12	
B	5032	261	1233	0	3	0	21	11	
B	5033	250	1233	0	3	0	21	11	
B	6424	306	1233	4631	3	3	19	15	
B	5034	240	1233	0	3	0	21	11	
B	5033	227	1233	0	3	0	23	12	
B	5037	217	1233	0	3	0	21	11	
B	5035	206	1233	0	3	0	21	11	
B	5035	175	1233	0	3	0	23	12	
B	5037	165	1233	0	3	0	23	12	
B	5036	154	1233	0	3	0	23	12	
B	5037	143	1233	0	3	0	23	12	
B	5042	133	1233	0	3	0	23	11	
B	5041	122	1233	0	3	0	21	11	
B	5043	111	1233	0	3	0	21	11	
B	5043	101	1233	0	3	0	19	10	
B	5047	70	1233	0	3	0	21	11	
B	5056	57	1233	0	3	0	21	10	
B	5064	47	1233	0	3	0	21	11	← END OF 1st ROUND TRIP

F-105
TOP ANTENNA

TABLE 5. F-105 FLIGHT TEST DATA, RUN 2, OUTBOUND, BOTTOM ANTENNA

RECORD # 561 SCAN # 286 FILE # 1

	AZ	RG	CODE	ALT	VA	VC	RL	MC
B	5361	134	1233	0	3	0	21	11
B	5332	145	1233	0	3	0	21	11
B	5303	156	1233	0	3	0	21	11
B	5262	167	1233	0	3	0	21	11
B	5246	200	1233	0	3	0	21	11
B	5230	211	1233	0	3	0	23	12
B	5215	222	1233	0	3	0	23	12
B	5202	232	1233	0	3	0	23	12
B	5172	243	1233	0	3	0	23	12
B	5162	253	1233	0	3	0	23	11
B	5153	263	1233	0	3	0	23	11
B	5147	274	1233	0	3	0	21	10
B	5140	304	1233	0	3	0	23	12
B	5134	315	1233	0	3	0	21	11
B	5126	326	1233	0	3	0	23	11
B	5122	336	1233	0	3	0	21	11
B	5117	347	1233	0	3	0	23	12
B	5114	360	1233	0	3	0	21	11
B	5107	371	1233	0	3	0	23	12
B	5102	402	1233	0	3	0	21	11
B	5075	413	1233	0	3	0	23	11
B	5073	424	1233	0	3	0	21	11
B	5070	435	1233	0	3	0	23	12
B	5066	446	1233	0	3	0	25	13
B	5066	460	1233	0	3	0	25	13
B	5061	470	1233	0	3	0	25	13
B	5056	501	1233	0	3	0	23	12
B	5055	512	1233	0	3	0	23	12
B	5053	523	1233	0	3	0	23	11
B	5052	535	1233	0	3	0	23	12
B	5045	545	1233	0	3	0	23	12
B	5045	556	1233	0	3	0	23	12
B	5043	570	1233	0	3	0	23	12
B	5043	600	1233	0	3	0	21	11
B	5037	611	1233	0	3	0	23	12
B	5037	622	1233	0	3	0	23	12
B	5034	634	1233	0	3	0	23	12
B	5034	645	1233	0	3	0	21	10
B	5035	656	1233	0	3	0	23	12
B	5034	667	1233	0	3	0	23	12
B	5033	700	1233	0	3	0	21	11
B	5031	712	1233	0	3	0	23	11
B	5031	723	1233	0	3	0	23	12
B	5031	735	1233	0	3	0	23	12
B	5026	746	1233	0	3	0	21	11
B	5032	760	1233	0	3	0	21	11
B	5026	772	1233	0	3	0	21	10
B	5027	1003	1233	0	3	0	21	11
B	5027	1015	1233	0	3	0	19	9
B	5030	1026	1233	0	3	0	19	10
B	5031	1040	1233	0	3	0	19	10
B	5030	1052	1233	0	3	0	19	10
B	5047	1063	1233	0	3	0	9	5
B	5027	1075	1233	0	3	0	21	11
B	5030	1106	1233	0	3	0	19	10
B	5030	1120	1233	0	3	0	21	11
B	5032	1131	1233	0	3	0	19	10
B	5027	1143	1233	0	3	0	19	10
B	5034	1155	1233	0	3	0	19	10
B	5027	1166	1233	0	3	0	19	10
B	5032	1200	1233	0	3	0	17	9
B	5032	1212	1233	0	3	0	17	9
B	5035	1223	1233	0	3	0	19	10
B	5035	1235	1233	0	3	0	19	10
B	5036	1246	1233	0	3	0	17	9
B	5040	1257	1233	0	3	0	15	8
B	5041	1271	1233	0	3	0	17	9
B	5043	1302	1233	0	3	0	15	8
B	5043	1314	1233	0	3	0	17	9
B	5050	1325	1233	0	3	0	17	9
B	5047	1337	1233	0	3	0	15	8
B	5050	1350	1233	0	3	0	17	9
B	5053	1362	1233	0	3	0	17	9
B	5052	1374	1233	0	3	0	17	9
B	5053	1406	1233	0	3	0	15	8

START OF 2nd RUN OUTBOUND FROM ACY

END OF OUTBOUND RUN

F-105
BOTTOM ANTENNA

TABLE 6. F-105 FLIGHT TEST DATA, RUN 3, OUTBOUND, TOP AND BOTTOM ANTENNAS

RECORD # 1321 SCAN # 63 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5213	42	1233	0	3	0	11	6	← START FROM ACY
B	5141	52	1233	0	3	0	13	5	
B	5123	63	1233	0	3	0	13	6	
B	5103	74	1233	0	3	0	13	5	
B	5061	105	1233	0	3	0	11	4	
B	5073	116	1233	0	3	0	13	6	
B	5064	130	1233	0	3	0	21	9	
B	5063	141	1233	0	3	0	13	7	
B	5046	152	1233	0	3	0	13	7	
B	5044	163	1233	0	3	0	21	8	
B	5040	174	1233	0	3	0	13	7	
B	5036	206	1233	0	3	0	21	9	
B	5032	217	1233	0	3	0	13	7	
B	5032	230	1233	0	3	0	21	9	
B	5031	242	1233	64	3	3	21	19	
B	5023	253	1233	64	3	3	20	15	
B	5024	264	1233	64	3	3	21	19	
B	5025	275	1233	63	3	3	21	18	
B	5022	306	1233	63	3	3	18	15	
B	5022	320	1233	63	3	2	22	19	
B	5020	331	1233	0	1	1	14	14	
B	5010	376	1233	64	3	3	15	15	
B	5010	407	1233	65	3	3	20	18	
B	5010	420	1233	65	3	3	21	20	
B	5014	432	1233	65	3	3	22	21	
B	5014	443	1233	64	3	3	14	14	
B	5007	454	1233	64	3	3	20	18	
B	5013	465	1233	64	3	3	22	21	
B	5012	476	1233	64	3	3	14	14	
B	5011	507	1233	64	3	3	20	17	
B	5010	521	1233	64	3	3	21	20	
B	5011	532	1233	64	3	3	21	19	
B	5010	543	1233	64	3	3	13	13	
B	5013	554	1233	64	3	3	13	12	
B	5007	565	1233	64	3	3	19	12	
B	5012	577	1233	64	3	3	20	14	
B	5004	610	1233	64	3	3	15	12	
B	5004	621	1233	64	3	3	13	8	
B	5044	622	1233	64	1	3	5	5	
B	5014	633	1233	64	3	3	13	10	
B	5021	644	1233	64	3	3	13	13	
B	5013	655	1233	64	3	3	21	17	
B	5015	700	1233	64	3	3	13	9	
B	5015	712	1233	64	3	3	19	10	
B	5006	723	1233	64	1	2	13	9	
B	5010	735	1233	64	3	3	13	9	
B	5004	747	1233	64	3	3	12	7	
B	5005	760	1233	64	3	3	13	8	
B	5014	772	1233	64	3	3	13	9	
B	5021	1003	1233	64	3	3	12	8	
B	5010	1014	1233	64	3	3	11	7	
B	5007	1026	1233	64	3	3	13	9	
B	5023	1040	1233	64	3	3	13	9	
B	5006	1051	1233	64	3	3	13	8	
B	5046	1051	1233	64	1	3	5	5	
B	5021	1063	1233	64	3	3	13	9	
B	5012	1075	1233	64	3	3	11	7	
B	5011	1106	1233	64	3	3	13	9	
B	5021	1120	1233	64	3	3	13	8	
B	5027	1131	1233	64	3	3	13	9	
B	5007	1143	1233	64	3	3	12	8	
B	5013	1154	1233	64	3	3	13	9	
B	5015	1166	1233	64	3	3	13	9	
B	5026	1177	1233	64	3	3	13	9	
B	5013	1210	1233	64	3	3	11	7	
B	5013	1222	1233	64	3	3	12	8	
B	5020	1233	1233	64	3	3	13	9	
B	5027	1244	1233	64	3	3	13	8	
B	5034	1255	1233	64	3	3	12	8	
B	5017	1266	1233	64	3	3	12	8	
B	5017	1277	1233	64	3	3	13	9	
B	5027	1310	1233	64	3	3	13	8	
B	5035	1321	1233	64	3	3	12	8	
B	5020	1331	1233	64	3	3	13	9	
B	5031	1343	1233	64	3	3	13	9	
B	5021	1353	1233	64	3	3	11	7	
B	5022	1364	1233	64	3	3	13	9	
B	5023	1375	1233	64	1	3	10	5	
B	5060	1400	1233	64	3	3	13	7	← END

F-105
BOTH ANTENNAS
OUTBOUND

TABLE 7. F-105 FLIGHT TEST DATA, RUN 3, INBOUND, TOP AND BOTTOM ANTENNAS

RECORD # 1430 SCAN # 113 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC
B	5062	1371	1233	65	3	3	10	6
B	5066	1351	1233	66	3	3	13	8
B	5075	1342	1233	65	3	3	11	7
B	5106	1332	1233	63	3	3	11	7
B	5103	1322	1233	63	3	3	11	6
B	5111	1312	1233	64	3	3	13	9
B	5124	1302	1233	64	3	3	13	9
B	5133	1272	1233	64	3	3	12	8
B	5141	1262	1233	64	3	3	11	7
B	5146	1252	1233	64	3	2	9	5
B	5142	1242	1233	64	3	3	13	8
B	5150	1232	1233	64	3	3	13	8
B	5167	1213	1233	64	3	3	13	9
B	5202	1203	1233	64	3	3	13	8
B	5175	1174	1233	64	2	3	11	7
B	5206	1164	1233	64	3	3	11	7
B	5215	1155	1233	64	3	3	12	8
B	5225	1146	1233	64	3	3	11	7
B	5235	1137	1233	64	3	3	11	7
B	5257	1130	1233	64	3	3	13	9
B	5266	1122	1233	64	3	3	12	8
B	5255	1113	1233	64	3	3	11	7
B	5264	1105	1233	64	3	3	11	7
B	5310	1077	1233	64	3	3	13	9
B	5320	1071	1233	64	3	3	13	9
B	5327	1063	1233	64	3	3	13	9
B	5334	1055	1233	64	3	3	12	8
B	5345	1047	1233	64	3	3	11	7
B	5357	1041	1233	64	3	3	12	8
B	5371	1034	1233	64	3	3	13	9
B	5402	1027	1233	64	3	3	13	9
B	5372	1021	1233	64	3	2	10	5
B	5403	1014	1233	64	3	3	13	8
B	5420	1007	1233	64	3	3	13	13
B	5436	1002	1233	64	3	3	13	13
B	5452	776	1233	64	3	3	13	12
B	5464	771	1233	64	3	3	12	12
B	5470	764	1233	64	3	3	18	14
B	5473	760	1233	64	3	3	13	11
B	5505	753	1233	64	3	3	12	12
B	5523	747	1233	64	3	3	12	12
B	5536	743	1233	64	3	3	13	13
B	5546	737	1233	64	3	3	18	15
B	5564	733	1233	64	3	3	14	13
B	5573	727	1233	64	3	3	13	13
B	5607	724	1233	64	3	3	20	19
B	5621	720	1233	64	3	3	19	17

← START FROM WATERLOO

RECORD # 1551 SCAN # 170 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC
B	5637	715	1233	64	3	3	13	13
B	5650	712	1233	64	3	3	14	14
B	5662	706	1233	64	3	3	19	18
B	5677	704	1233	64	3	3	19	19
B	5714	701	1233	64	3	3	18	18
B	5732	676	1233	64	3	3	14	14
B	5736	673	1233	64	3	3	13	9
B	5765	670	1233	64	3	3	13	9
B	5767	661	1233	63	3	3	12	8
B	5772	651	1233	63	3	2	12	7
B	5773	641	1233	64	3	3	13	9
B	5774	631	1233	64	3	3	13	12
B	5777	620	1233	63	3	3	13	8
B	5765	577	1233	64	3	3	12	8
B	5770	567	1233	64	3	3	13	9
B	5772	556	1233	0	3	0	13	5
B	6006	535	1233	64	1	3	13	8
B	6025	524	1233	64	1	2	5	5
B	5775	513	1233	64	3	3	11	7
B	5775	502	1233	64	3	3	12	8
B	5775	471	1233	64	3	3	13	9
B	6007	460	1233	64	3	3	13	9
B	6000	447	1233	64	3	3	10	6
B	6003	436	1233	64	3	3	13	8
B	6043	436	1233	64	3	2	5	5
B	6015	425	1233	64	3	3	13	11
B	6025	414	1233	64	3	3	13	9
B	6030	402	1233	63	3	3	12	8
B	6022	370	1233	63	3	3	19	13
B	6011	357	1233	64	3	3	12	8
B	6016	345	1233	64	3	3	13	9
B	6030	333	1233	65	3	3	13	9
B	6037	321	1233	65	3	3	13	13
B	6044	307	1233	65	3	3	13	13
B	6047	275	1233	65	3	3	13	13
B	6055	264	1233	65	3	3	14	14
B	6065	251	1233	64	3	3	22	20
B	6071	237	1233	63	3	3	20	19
B	6100	225	1233	63	3	3	21	20
B	6110	213	1233	63	3	3	19	17
B	6131	201	1233	63	3	3	20	20
B	6134	167	1233	63	3	3	21	21
B	6161	155	1233	63	3	3	22	21
B	6176	144	1233	64	3	3	22	21
B	6224	132	1233	64	3	3	22	21
B	6255	120	1233	64	3	3	21	21
B	6315	107	1233	64	3	3	21	21

F-105
INBOUND
BOTH ANTENNAS
(A/C FLEW AN
OFFSET RADIAL
AT REQUEST OF
LOCAL TRAFFIC CONTROL-
RESULTED IN AZ CHANGES
DURING RUN)

← END

TABLE 8. F-106 FLIGHT TEST DATA, OUTBOUND, TOP AND BOTTOM ANTENNAS

RECORD # 1484 SCAN # 138 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5005	635	1234	104	3	3	12	12	← START OUTBOUND FROM ACY
B	5013	643	1234	104	3	3	13	12	
B	4777	651	1234	104	3	3	13	9	
B	5004	656	1234	104	3	3	12	10	
B	5010	663	1234	105	3	3	12	11	
B	5014	671	1234	105	3	3	13	13	
B	5017	676	1234	105	3	3	16	15	
B	5021	703	1234	105	3	3	15	15	
B	5023	711	1234	105	3	3	19	17	
B	5035	716	1234	105	3	3	28	24	
B	5025	724	1234	105	3	3	13	12	
B	5027	731	1234	105	3	3	18	16	
B	5030	736	1234	105	3	3	18	18	
B	5032	744	1234	105	3	3	19	18	
B	5033	751	1234	105	3	3	19	17	
B	5034	756	1234	105	3	3	19	19	
B	5037	763	1234	105	3	3	19	18	
B	5032	771	1234	106	3	3	12	10	
B	5035	776	1234	106	3	3	13	11	
B	5041	1003	1234	106	3	3	13	12	
B	5041	1011	1234	107	3	3	12	11	
B	5045	1016	1234	107	3	3	13	12	
B	5052	1023	1234	107	3	3	13	10	
B	5051	1030	1234	107	3	3	20	16	
B	5043	1035	1234	106	3	3	14	13	
B	5044	1043	1234	106	3	3	13	8	
B	5051	1050	1234	106	3	3	12	9	
B	5054	1055	1234	105	3	3	12	10	
B	5056	1063	1234	105	3	3	13	12	F-106 TWO ANTENNAS
B	5061	1070	1234	105	1	3	13	12	
B	5044	1076	1234	105	3	3	12	8	
B	5055	1103	1234	106	3	3	12	8	
B	5045	1111	1234	106	3	3	11	7	
B	5052	1116	1234	106	3	3	13	8	
B	5061	1123	1234	107	3	3	12	8	
B	5065	1131	1234	107	3	3	13	12	
B	5066	1136	1234	107	3	3	13	13	
B	5064	1144	1234	107	3	3	20	17	
B	5056	1151	1234	107	3	3	14	9	
B	5066	1157	1234	107	3	3	13	12	
B	5071	1164	1234	107	3	3	19	15	
B	5070	1171	1234	106	3	3	21	19	
B	5072	1177	1234	106	3	3	21	17	
B	5064	1204	1234	105	3	3	13	10	
B	5065	1212	1234	105	3	3	12	8	
B	5073	1220	1234	105	3	3	12	12	
B	5070	1226	1234	105	3	3	18	13	
B	5072	1233	1234	105	3	3	18	11	
B	5057	1241	1234	105	3	2	11	6	
B	5066	1247	1234	105	3	3	13	10	
B	5065	1254	1234	105	3	3	13	9	
B	5067	1262	1234	106	3	3	13	8	
B	5073	1270	1234	106	3	3	12	8	
B	5077	1275	1234	106	3	3	12	8	
B	5104	1303	1234	107	3	3	12	8	
B	5103	1310	1234	107	3	3	10	6	
B	5073	1316	1234	107	1	3	10	5	
B	5073	1323	1234	110	3	3	13	8	
B	5077	1331	1234	110	3	3	12	8	
B	5060	1336	1234	110	3	3	12	8	
B	5062	1344	1234	110	3	3	14	10	
B	5065	1351	1234	110	3	3	13	10	
B	5072	1356	1234	107	3	3	13	8	← END

TABLE 9. F-106 FLIGHT TEST DATA, INBOUND, TOP AND BOTTOM ANTENNAS

RECORD # 1591 SCAN # 189 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5047	1347	1234	103	3	3	16	16	← START F-106 INBOUND FROM WATERLOO
B	5047	1341	1234	103	3	3	19	19	
B	5050	1334	1234	103	3	3	18	18	
B	5050	1326	1234	104	3	3	15	15	
B	5044	1321	1234	104	3	3	20	19	
B	5046	1313	1234	105	3	3	19	19	
B	5046	1306	1234	105	3	3	16	16	
B	5047	1300	1234	105	3	3	16	16	
B	5043	1273	1234	105	3	3	19	19	
B	5044	1266	1234	105	3	3	19	19	
B	5043	1260	1234	105	3	3	18	17	
B	5043	1253	1234	106	3	3	21	20	
B	5043	1246	1234	106	3	3	18	18	
B	5044	1240	1234	106	3	3	18	17	
B	5042	1233	1234	106	3	3	18	18	
B	5043	1225	1234	106	3	3	19	19	
B	5044	1220	1234	107	3	3	19	19	
B	5043	1213	1234	107	3	3	19	18	
B	5042	1205	1234	107	3	3	21	20	
B	5041	1177	1234	107	3	3	20	20	
B	5042	1172	1234	106	3	3	20	20	
B	5042	1165	1234	106	3	3	22	22	
B	5041	1157	1234	106	3	3	21	21	
B	5037	1152	1234	106	3	3	21	21	
B	5041	1144	1234	106	3	3	21	21	
B	5041	1137	1234	106	3	3	21	21	
B	5041	1132	1234	106	3	3	20	20	
B	5041	1124	1234	105	3	3	21	21	
B	5043	1117	1234	105	3	3	21	19	
B	5040	1111	1234	105	3	3	23	23	
B	5040	1104	1234	105	3	3	21	21	
B	5042	1076	1234	105	3	3	22	22	
B	5041	1071	1234	105	3	3	19	19	
B	5037	1064	1234	105	3	3	20	19	
B	5041	1056	1234	105	3	3	21	21	
B	5041	1051	1234	105	3	3	22	22	
B	5037	1044	1234	105	3	3	21	21	
B	5042	1036	1234	105	3	3	21	21	
B	5041	1031	1234	105	3	3	21	20	
B	5036	1024	1234	105	3	3	22	21	
B	5040	1016	1234	104	3	3	20	20	
B	5037	1011	1234	104	3	3	19	19	
B	5036	1004	1234	104	3	3	13	12	
B	5046	777	1234	105	3	3	13	10	
B	5032	772	1234	105	3	3	12	8	
B	5042	765	1234	106	3	3	12	11	
B	5043	760	1234	106	3	3	20	18	
B	5042	753	1234	105	3	3	21	19	
B	5053	746	1234	105	3	3	20	20	
B	5046	741	1234	105	3	3	19	18	
B	5047	733	1234	105	3	3	20	19	
B	5053	726	1234	106	3	3	20	20	
B	5054	721	1234	106	3	3	19	18	
B	5046	714	1234	106	3	3	21	21	
B	5054	706	1234	106	3	3	21	21	
B	5052	701	1234	107	3	3	23	20	
B	5052	673	1234	107	3	3	21	21	
B	5057	666	1234	107	3	3	22	22	
B	5056	661	1234	107	3	3	19	18	
B	5051	653	1234	107	3	3	21	21	
B	5054	645	1234	107	3	3	23	22	
B	5053	637	1234	107	3	3	21	21	
B	5054	631	1234	106	3	3	21	20	

RECORD # 1826 SCAN # 295 FILE # 2

	AZ	RG	CODE	ALT	VA	VC	RL	HC	
B	5056	623	1234	106	3	3	20	18	
B	5057	615	1234	106	3	3	20	19	
B	5065	610	1234	106	3	3	21	20	
B	5070	602	1234	107	3	3	20	19	
B	5062	574	1234	107	3	3	20	20	
B	5071	566	1234	107	3	3	20	20	
B	5063	560	1234	107	3	3	21	21	
B	5067	552	1234	107	3	3	21	21	
B	5070	545	1234	107	3	3	22	22	
B	5066	537	1234	106	3	3	21	21	
B	5072	531	1234	106	3	3	22	22	
B	5075	523	1234	106	3	3	22	22	
B	5074	515	1234	106	3	3	21	20	
B	5074	507	1234	106	3	3	22	22	
B	5075	501	1234	105	3	3	22	22	
B	5071	473	1234	105	3	3	21	20	
B	5076	465	1234	105	3	3	23	23	
B	5101	457	1234	105	3	3	23	23	
B	5075	451	1234	104	3	3	24	22	
B	5102	443	1234	104	3	3	22	22	
B	5103	435	1234	104	3	3	24	23	
B	5103	427	1234	104	3	3	22	22	
B	5077	421	1234	104	3	3	22	21	
B	5103	413	1234	105	3	3	22	22	
B	5104	405	1234	105	3	3	22	20	
B	5100	377	1234	106	3	3	22	21	
B	5100	372	1234	106	3	3	22	22	
B	5077	364	1234	107	3	3	21	21	
B	5100	357	1234	107	3	3	21	20	
B	5076	351	1234	107	3	3	13	10	
B	5101	344	1234	110	3	3	22	22	
B	5101	337	1234	110	3	3	22	22	
B	5101	332	1234	111	3	3	22	22	
B	5100	325	1234	110	3	3	21	21	
B	5076	317	1234	110	3	3	22	22	
B	5075	312	1234	107	3	3	22	21	
B	5073	305	1234	107	3	3	23	22	
B	5072	300	1234	106	3	3	22	22	
B	5066	273	1234	105	3	3	22	22	
B	5065	265	1234	105	3	3	23	23	
B	5064	260	1234	104	3	3	23	23	
B	5063	252	1234	104	3	3	24	24	
B	5062	245	1234	104	3	3	23	23	
B	5062	240	1234	104	3	3	22	21	
B	5063	233	1234	104	3	3	23	23	
B	5064	226	1234	104	3	3	21	21	
B	5066	221	1234	104	3	3	22	21	
B	5065	214	1234	104	3	3	21	21	
B	5067	207	1234	105	3	3	21	19	
B	5071	202	1234	105	3	3	21	18	
B	5065	175	1234	105	3	3	13	8	
B	5070	170	1234	105	3	3	13	8	
B	5072	163	1234	106	3	3	13	9	
B	5075	156	1234	106	3	3	11	7	
B	5106	151	1234	106	3	3	19	17	
B	5101	143	1234	107	3	3	21	20	
B	5105	136	1234	107	3	3	22	22	
B	5111	130	1234	107	3	3	21	21	
B	5107	123	1234	107	3	3	14	13	
B	5121	116	1234	110	3	3	21	20	
B	5126	110	1234	111	3	3	21	19	
B	5136	103	1234	111	3	3	22	22	
B	5146	75	1234	120	3	3	21	21	
B	5165	70	1234	120	3	3	20	20	
B	5216	62	1234	111	3	3	20	20	
B	5243	55	1234	110	3	3	23	21	
B	5304	47	1234	110	3	3	24	22	
B	5357	41	1234	107	3	3	23	23	← END

F-106. As observed from the hit count readings in table 2, the number of replies were approximately 11 to 12 as the F-105 was inbound to begin his first run. The hit count decreased to approximately 5 in the cone of silence fringe area, then increased to a maximum of 8 to 9, then decreased to about 4 as the aircraft started to turn at Waterloo (see table 2). The inbound leg increased to about 12 replies as the top antenna was reasonably unobstructed or unshielded on the inbound leg. It is noted that the run length was twice the hit count minus one, i.e., 2 x HC-1 (for hit count of 12, the run length was 23). This coincides with the site 1:1 interlace pattern since the pilot did not have mode C (altitude) turned on.

The data from the second run (bottom antenna only) indicates a hit count of 11 to 12 at the start, with a gradual decrease to 8 to 9 at Waterloo when he began his turn. The aircraft was not detected with even a single hit on the inbound leg. The next reply, after the turn at Waterloo, came after the aircraft had passed over the site and was outbound again. Run length of the outbound was, again, approximately twice the hit count.

The third run was with mode C on and the antennas automatically switched (alternating) between the top and bottom at the 38 Hz rate. The aircraft flew about 10 miles offset from the radial on the inbound leg at the request of local air traffic control. This resulted in partial visibility of the bottom antenna and some replies from the bottom antenna were recorded. As indicated by the data, both the hit count and run length were good and solid from about 9 miles out to approximately 21 miles. At this point, both hit count and run length began decreasing to 8 to 9 hits at 28 miles. This remains reasonably constant for the remainder of the outbound leg. The inbound hit count and run length were reasonably constant at 8 to 9 in to about 32 miles, at which point the hit count jumped significantly. At about 25 miles the count dropped significantly and displayed variations in to about 12 miles. The remainder of the inbound leg remained good.

The F-106 flight showed some minor fluctuations in hit count out to about 40 miles, where the count decreased. The inbound leg showed immediate improvement when the aircraft began the inbound leg. With few exceptions, this showed good solid hit count and run length.

IMPACT ON ARTS.

It is evident from the data presented that high performance military aircraft, particularly F-105's, present problems in the ATCRBS fringe areas of coverage. The operational ARTS systems very frequently have high hit count requirements for target declaration to reduce/eliminate false targets and ring-around. Hit count requirements of 11 for 3A/C and 7 for 3A only are not unusual in the field systems. In these systems the F-105 would have been lost for significant portions of the flight. For example, it would have been lost from about 32 miles out on the outbound leg of the first run. The inbound leg would probably have been tracked, but would have been marginal or intermittent. The outbound leg with the bottom antenna would probably have been tracked to the turn at Waterloo. Again, the inbound leg was never detected or tracked. With the antennas alternating at 38 Hz, the F-105 would not have been tracked in an operational ARTS with an 11-hit count requirement beyond approximately 28 miles on the outbound, and would have been picked up again at about 32 miles on the inbound leg. The target would have been intermittent from that point in to about 12 miles, where it would have been solid.

The F-106 would have been tracked on the operational ARTS system with firm code and altitude validation with only one or two holes on the outbound leg out to about 40 miles. The target would have been lost at this point. The inbound leg was solid all the way, except one hole

for four antenna scans where the target would have been lost.

It is again noted that the tracking data are for 4,500 foot altitudes. These data would be significantly different at higher altitudes and would show different pattern and shielding effects.

The coverage problems appear to be with the older type aircraft and have existed since introduction of the specific aircraft into the military fleet. The introduction of sophisticated air traffic control equipment, such as ARTS and NAS, has significantly magnified the effects of the problems with the more stringent input data requirements. In short, holes or gaps in the run length were not so noticeable in the older broad band systems because the display phosphors and the human eye tended to integrate the target blip. The new digital systems are sensitive to even 1 hit/miss in marginal conditions (e.g., a difference from 10 to 11 hits means the difference in target declaration at some facilities). It is also believed that holes of 10 misses (sliding window width in the NAS) could result in target splits in the NAS.

The new dual diversity antenna system used in the F-16 would alleviate the coverage problem in older aircraft; however, it is highly improbable that these aircraft would be retrofitted from the economic factor alone. A large percentage of the aircraft are obsolete and assigned to Air National Guard or reserve activities.

CONCLUSIONS

It is concluded that:

1. The F-105 and similar type military aircraft present serious tracking problems in the Automated Radar Terminal System (ARTS), particularly in the low altitude fringe areas of coverage.

2. A dual diversity antenna system of the type used in the F-16 aircraft would alleviate the coverage problem; however, older obsolete aircraft would not be retrofitted due to economics.

3. Reduction of the ARTS hit count parameter HY4, in those facilities with high values, would improve tracking of the high performance aircraft.

RECOMMENDATIONS

It is recommended that:

1. Automated radar terminal system (ARTS) and National Airspace System (NAS) facilities that experience difficulties in coverage of military aircraft reduce the hit count or sliding window requirement for target declaration to 7 hits. This would enable target declaration during one switch time (half cycle) of the aircraft antenna.

2. The possibility of modifying approach/departure patterns at military air bases be investigated to provide more broad side visibility to the Air Traffic Control Radar Beacon System (ATCRBS).

3. Air traffic controllers be familiarized with the military ATCRBS characteristics with the view point of possibly changing procedures in problem areas and/or requesting the pilot to select top or bottom antenna (on aircraft with that capability) to provide better coverage.

4. Additional investigation and analysis be jointly conducted by the Federal Aviation Administration (FAA) and the United States Department of Defense (DOD) to determine what improvements, if any, can be made.

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